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Potential Welfare Impacts of Chase and Capture of Small Cetaceans During Drive Hunts in Japan

Courtney S. Vail[1], Diana Reiss[2], Philippa Brakes[3, 4], Andrew Butterworth[5]

[1]Lightkeepers, Phoenix, AZ, USA; [2]Department of Psychology, Hunter College, City University of New York, New York, NY, USA; [3]Centre for Ecology and Conservation, University of Exeter, Tremough, Cornwall, UK; [4]Whale and Dolphin Conservation (WDC), Wiltshire, UK; [5]Clinical Veterinary School, University of Bristol Veterinary School, Langford, UK

Abstract

Drive hunts are a method to herd, capture and kill small cetaceans (whales and dolphins) in coastal waters of some countries including Japan and the Faroe Islands. In Japan, these methods are often associated with the acquisition of live dolphins for international marine parks and aquaria. During the hunts, dolphins are herded by a flotilla of fishing vessels and loud underwater noise created by fishermen banging hammers on metal poles. The prolonged and strenuous chase and use of sound barriers to herd, capture, and restrain the dolphins can result in acute stress and injury. The authors review physiological and behavioural data pertaining to chase, encirclement, and live capture of dolphins and draw comparisons between chase and capture data for marine and terrestrial species. This analysis raises substantial welfare concerns associated with the hunts and acquisition of dolphins from such capture operations. The authors assert that this data detailing the negative impacts of chase, herding and handling (capture) of small cetaceans renders these hunts inherently inhumane and should inform policy relating to the collection and management of dolphins in the wild.

Introduction

Drive hunts are a method used to herd, capture and kill small cetaceans (whales and dolphins) in the coastal waters of some countries including Japan and the Faroe Islands. In Japan, the animals are herded by a flotilla of fishing vessels (Figure 1) and a cacophony of underwater noise is created by fishermen banging hammers on specifically designed trumpet-shaped metal poles (Figures 2 (a,b)). The practice generates powerful acoustic signals (greater than 170 dB) which are transmitted through the water inducing flight, escape and avoidance behavior in the animals pursued in these hunts. This is known as the Oikomi method (Akamatsu, Hatakeyama, & Takatsu, 1993; Brownell, Nowacek, & Ralls, 2008; Ohsumi, 1972) and it is used to drive cetaceans into harbors or shallow coves where they will be either killed, or selected for display in marine parks and aquaria. The main species taken in the Japanese drive hunts include: common bottlenose dolphins (*Tursiops truncatus*), striped dolphins (*Stenella coeruleoalba*), Risso's dolphins (*Grampus griseus*), false killer whales (*Pseudorca crassidens*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), pantropical spotted dolphins (*Stenella attenuata*), and short-finned pilot whales (*Globicephala macrorhynchus*). More recently, melon-headed whales (*Peponocephala electra*) and rough-toothed dolphins (*Steno bredanensis*) have been added to the targeted species list. Quotas of over 2,000 dolphins and small whales are issued annually for these specific hunts (Kasuya, 2007).

In a previous report, we describe and discuss the killing methods and techniques employed in the drive hunts and why they do not conform to the recognized requirements for humane killing methods that render "immediate insensibility" and thus would not be permitted in any regulated slaughterhouse process in the developed world (Butterworth et al., 2013).

Figure 1. A fleet of boats returns from a dolphin drive hunt in Taiji, Japan. Image: DolphinProject.com

Figure 2. (a) Metal trumpets utilized in the dolphin drive hunts. (b) Trumpets (indicated by circle) are mounted on vessels and placed in the water. Using a hammer or other object, fishermen bang on the poles to create loud noise (up to 205dB) that disorients the dolphins. Image: Courtney Vail

In this paper, we focus on the chasing, herding, separation and confinement of animals during the drive hunt process, and review the existing literature and other available data on the physical, behavioral and social impacts of these activities on cetaceans. This data is compared to existing data on the impact of hunt and acquisition activities in other species. We raise questions about the potential welfare and conservation implications of the methods used in the drive hunts and highlight the notable absence of scientific data applied in policies governing dolphin management and acquisition.

Acoustic Impacts: an aversive wall of sound

During the drive hunts in Japan, the aversive wall of sound is created by the combination of boat engine noise and repetitive banging on the long metal trumpets. Brownell et al. (2008, p.82) report that:

> "When a scouting boat finds a school, it reports to the office on shore and 10 to 20 driving boats are sent to surround the school and drive it, by making noise underwater with 'trumpets' (Kasuya, 2002), into the bay of the village where the dolphins are stranded on the beach or surrounded with a long net and killed."

Akamatsu et al. (1993) assessed the action of the metal trumpets and showed that the sound was effective in causing the animals to swim directly away from the source at received levels of 170 dB re: 1mPa. The same researcher also reported that these trumpets, also known as banger poles, could produce sound at 205dB re: 1mPa at 0.2-5.2kHz. Both 174dB and 205 dB are 'extremely loud' sound levels (louder than a jet engine at close proximity) and in shallow water and where the sound propagates outward in a concentric ring, cetaceans at ranges of up to approx. 1200m (1.2km) can potentially receive sound levels capable of eliciting strong behavioral responses. Brownell et al. *(*2008, p. 86) concluded that:

> "It is not surprising that Japanese fishermen, using two of these [trumpets] on each of several vessels at the same time, are able to herd schools of small cetaceans from tens of kilometres offshore into harbours, or cause them to mass-strand on beaches."

Anthropogenic sound is a potential stressor for marine mammals that affects psychological and physical health, as has been demonstrated in other mammals (Romano et al., 2002; Tyack, 2008). The primary sense of cetaceans is hearing and they are reliant on sound continuously for multiple social and biological functions such as foraging, navigation, maintaining social contact with members of their social group, breeding, and threat avoidance. The exposure to high levels of noise, and especially to prolonged exposure to noise, will negatively impact many of these important functions (Tyack & Clark, 2000; Wright et al., 2007a, 2007b). Noise, has been defined as "essentially as an aperiodic signal that interferes with the perception of sound and has a negative physiological impact" (Ketten, 2016, p.208).

Although cetaceans use a rich variety of multi-modal signals (e.g., behavioral, spatial, and tactile), they rely heavily on acoustic communication to maintain contact, both at close range, and also at longer distances. Many toothed cetaceans use wide-band sonar signals for navigation and orientation and use a rich repertoire of frequency-modulated whistles and pulsed calls for communication and cohesion between group members (Brown, Caldwell, & Caldwell, 1966; Esch, Sayigh, Blum, & Wells, 2009; McCowan & Reiss, 1995). With disrupted capacity to communicate, the animals may experience social disorientation, increased stress and loss of ability to use acoustic senses (Tyack, 2008; Weilgart, 2007). Elevated background noise levels have been identified as a source of interference in marine mammals' ability to detect calls from other individuals, and may result in long-term displacement or abandonment of important habitat where resting, feeding, breeding, migratory patterns, and social interactions are interrupted through noise disturbance (Fair & Becker, 2000; Nowacek, 2007; Richardson & Wursig, 1997; Tyack, 2008; Weilgart, 2007).

It has been well-documented that repeated exposure to loud noises may result in physical hearing loss. Noise-induced ear damage has been reported and can also be detrimental and negatively impact navigation, diving, foraging, communication, and group cohesion (Wright et al., 2007a). Noise has the potential to induce temporary hearing loss also known as temporary threshold shift (TTS), if it is loud or long enough in duration. In general, the higher the sound level and/or longer the duration, the more likely TTS is to occur. If exposure is prolonged or repeated or even as a result of one very loud noise event, the hearing damage can become permanent, also known as a permanent threshold shift (PTS) (Finneran, 2015; Tyack, 2008; Weilgart, 2007). Although progress has been made in understanding the potential adverse effects of noise on marine mammal hearing, much remains unknown on how exposure to high dB levels and impulsive sounds can result in acute or chronic hearing deficits in marine mammal hearing (Finneran, 2015).

Wright et al. (2007a) integrated the available information on noise and stress responses in terrestrial mammals and contended that this can be extrapolated to cetaceans and other marine mammals because stress responses to noise appears to be highly conserved across all the species studied. Thus, for cetaceans as in other mammals, noise is a stressor that may result in "suppression of reproduction (physiologically and behaviorally), accelerated aging and sickness-like symptoms" (Wright et al., 2007b, p. 275). When dolphins cannot remove themselves from prolonged and loud sounds, in addition to physiological stress, damage to overall fitness can also result (Finneran, 2015; Tyack, 2008; Wright et al., 2007a). Changes in the profile of blood parameters have been linked to the effects of noise in cetaceans, altering immune competence in individuals which may have far-ranging consequences for targeted individuals and populations over time (Romano et al., 2004; Thomas, Kastelein, & Awbrey, 1990).

During drive hunts, the repeated and prolonged transmission of high-amplitude sound generated by the metal trumpets and the noise of the boat engines, creates noise at potentially damaging dB levels for these animals and very likely disrupts communication between individuals and groups. The acoustic onslaught experienced by cetaceans during the drive hunts is significant and may negatively impact them in many ways. Importantly, the cumulative multiple stressors resulting from ear damage and the stress responses to noise itself can affect both survivorship and reproduction, thus impacting both the welfare of individuals and health of populations.

Physical impact: handling, restraint and injury

Once sequestered in the cove, the dolphins are sometimes held up to five days before they are selected for slaughter, segregated and taken to sea pen holding facilities where they will eventually be distributed to aquaria, or released. Injury may occur during this selection process. For those individuals selected for slaughter, they are roped around their tails (caudal peduncle), and then towed to the killing area while still alive (see Supplementary Video 1).

Analysis of video of this activity shows that when dolphins are driven close to shore, they exhibit very rapid respiration rates. When forcibly submersed, they lack the capacity to control the duration of their submersion and display profound distress (Butterworth et al., 2013). Diving mammals are highly adapted for submersion, and capable of relatively long intervals between respirations (compared to terrestrial mammals). Diving animals are also capable of storage of oxygen in blood and tissue, and of bradycardia (slowing of the heart rate), adaptations that can extend the dive interval (Castellini, Davis, & Kooyman, 1988; Eckert, Eckert, Ponganis, & Kooyman, 1989; Williams, Haun, & Friedl, 1999). It is our contention that, despite the formidable adaptations to diving of toothed whales, some cetaceans may be drowned or asphyxiated (i.e., die from failure to be able to breathe through voluntary apnea, as opposed to entry of water into the lungs) during submersion and that many animals are subject to profound respiratory challenges during this process. Drowning or asphyxiation, resulting from forced restraint, would not be permitted in any accepted slaughter process for terrestrial mammals, and this highly aversive mechanism for killing these air-breathing animals has not been formally assessed during discussions on the ethics of small cetacean drive hunts (Figure 3).

Individual dolphins, including calves, are sometimes released so as not to violate species or seasonal quotas. This selection process involves the rough handling of individuals that are often struggling against the nets or exhausted from the chase and herding. Individuals that are selected for marine parks are held in the cove and often removed days after the chase and slaughter has ended. Video footage from documentaries and other images readily available in the media reveal injured dolphins with obvious physical trauma (i.e., bloodied areas on the body) from the handling and restraint associated with selection for marine parks and relocation to the shoreline (Figure 4). Permission to hunt Pacific white-sided dolphins was granted in 2007 and requires special nets (Hiroyuki, 2011). This species is taken primarily for live capture for aquaria, but the capture process—although conducted offshore and outside the confines of the cove—involves the same chase and capture methods, and potential for injury.

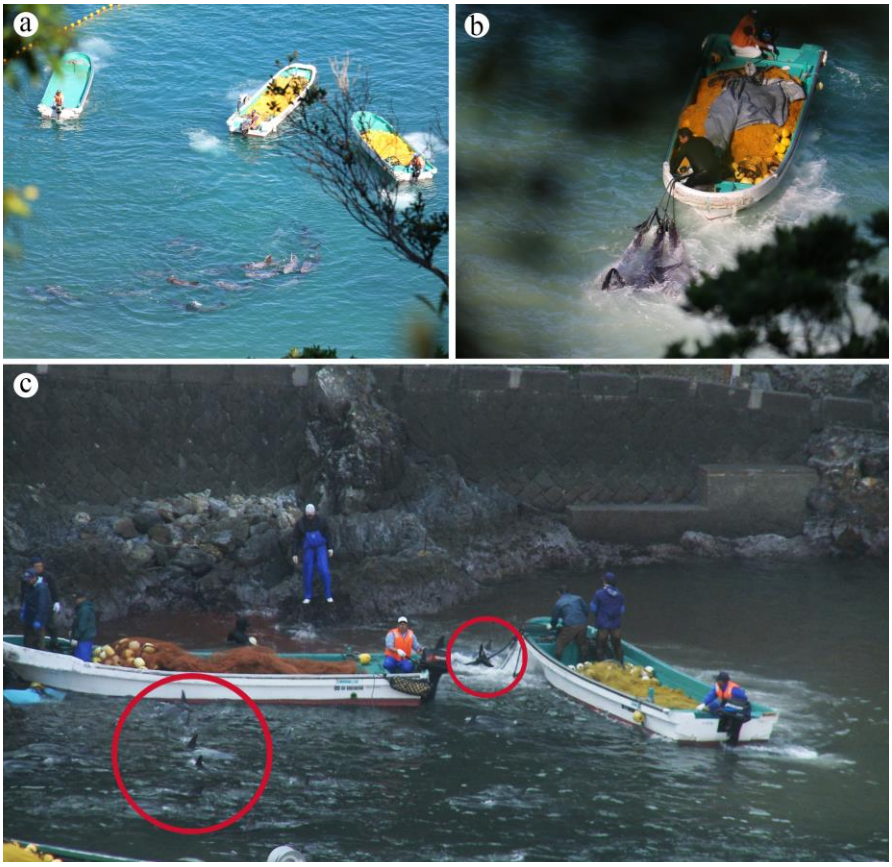

Figure 3. (a) A group of Risso's dolphins is corralled behind nets at the conclusion of a drive hunt. Image: DolphinProject.com/Marna Frida Olsen. (b) After chase and confinement in a cove, live Risso's dolphins are tethered and towed. Image: DolphinProject.com/Marna Frida Olsen. (c) While still alive, struggling dolphins are tethered by their tails for towing to the slaughter area (indicated by smaller circle). Other free-swimming dolphins (indicated by larger circle) are in close proximity to those tethered. Image: AtlanticBlue.de

Figure 4. (a) A dolphin is secured in a net after selection for a marine park. Image: Sea Shepherd Conservation Society. (b) An obviously injured dolphin being restrained during selection for a marine park after a drive hunt. Image: Sea Shepherd Conservation Society

The impacts of physical trauma associated with the chase and herding process is also evidenced by individual dolphins that strand and die after the hunts have concluded, often washing ashore days later (see https://www.youtube.com/watch?v=IVCHdNc13cc). According to eye-witness accounts, dolphins selected for release rarely leave the cove on their own—rather, they are chased and forced back out to sea by the fishermen (L. Lemieux, personal communication, August 5, 2018). These individuals are severely traumatized and disoriented from the process of the hunts. Pelagic species such as striped dolphins appear to panic in shallow water, throwing themselves onto sharp rocks as they avoid their pursuers in the cove (Supplementary Video 2). Releasing calves or over-quota animals during the hunt may contribute to other hidden or indirect mortality currently not monitored or quantified. Once released, the fate of these individuals injured or traumatized by the chase, handling, and proximity to the slaughter of their pod mates, is unknown.

International guidelines governing handling before slaughter

Recommendations adopted by consensus among the veterinary authorities of the World Organization for Animal Health (OIE), an intergovernmental organization responsible for improving animal health worldwide, state that all animals slaughtered outside slaughterhouses should be managed to ensure that their transport, lairage, restraint and slaughter is carried out without causing undue stress to the animals, including handling in such a way as to avoid harm, distress or injury (Shimshony & Chaudry, 2005; World Organization for Animal Health, 2011). Under the OIE, Japan has an obligation to uphold these principles. These recommendations also include guidelines that would specifically apply to the methods deployed during the drive hunt process, including prohibition against conscious animals being thrown, dragged or dropped; avoidance of excessive pressure that causes struggling or vocalization in animals; excessive shouting or making loud noises that may agitate the animals; and suspending or hoisting animals by the feet or legs. The handling, restraint and transportation of cetaceans violates these guidelines.

Socio-psychological and ecological impacts

Observational and experimental research conducted in the field and laboratory has demonstrated that dolphins exhibit high levels of cognitive and social complexity, including advanced social and self-awareness, sophisticated social learning, tool use, vocal and social imitation, the ability to comprehend symbolic gestural "sentences", self-organized learning, metacognition, and cultural transmission (Connor, Watson-Capps, Sherwin, & Krützen, 2011; Herman, Richards, & Wolz, 1984; Herman, 2002; Krützen et al., 2005; Mann & Singh, 2015; Mann & Smuts, 1999; Marino et al, 2007; Reiss & Marino, 2001; Reiss and McCowan, 1993; Smith et al, 1995; Whitehead, Rendell, Osborne, & Wursig, 2004). Notably, advanced social awareness has been well-documented in young dolphins (Connor & Krützen, 2015; Gibson & Mann, 2008; Mann & Smuts, 1999) and young bottlenose dolphins show the emergence of self-awareness, demonstrated by mirror-self recognition, at an age earlier than reported for children and apes (Morrison & Reiss, 2018). Dolphins in Shark Bay, Australia, use sponges as tools during foraging. The practice of "sponging" appears to be transmitted culturally and has been attributed to an almost exclusive vertical social transmission within a single matriline from mother to female offspring (Krützen et al., 2005). Bottlenose dolphins live in complex social groups, exhibiting fission-fusion type social organization in which the size and composition of groups are dynamic, and social factors, such as alloparental care, can contribute to variation in individual reproductive fitness in this species (Frère et al., 2010). Dolphins are mutually-dependent, form long-lasting social alliances that may be more complex than exhibited by other non-human species, and exhibit high levels of social awareness and social cognition (Connor & Krützen, 2015; Connor, 2007). Dolphins are social learners and have an extended period of juvenile dependency during which time youngsters are cared for by, and learn from, their mothers and other members of the social group (Connor, Read, & Wrangham, 2000; McCowan & Reiss, 1995; Reiss, McCowan, & Marino, 1997; Whitehead, 2010). Although precocious at birth, young dolphins are highly vulnerable, requiring a high degree of parental care and energy investment by mothers and alloparents (Gibson & Mann, 2008; Gubbins, McCowan, Lynn, Hooper, & Reiss, 1999; Noren, 2008).

Dolphins show altruistic and epimeletic (caregiving) behavior towards members of their group and other cetacean species, including assisting pregnant females during delivery, alloparenting, and supporting injured or ill animals (Bearzi et al., 2018; Brown et. al., 1966; Cockcroft & Sauer, 1990; Connor & Norris, 1982; Kuczaj et al., 2015; Park et al., 2013; Pilleri, 1984; Wells, 1991; Whitehead, 1996). Dolphins emit distress calls (Lilly, 1963) and the emission of these calls has been reported to elicit epimeletic behavior in other members of the social group (Kuczaj et al., 2015). Vocalizations of distressed dolphins during these hunts can have a psychological and physiological impact on other individuals in the group.

This high level of social awareness in both adult and young dolphins supports the view that the chase, encirclement, capture and removal of individuals from their social groups can have both negative psychological and social impacts. During the hunt process, dolphins are in close proximity to each other when individuals are removed from the group or killed. Individuals held for selection or slaughter are likely to be in a state of extreme anxiety, when they experience and witness the capture and killing of others individuals to whom they may be related or share close social bonds (Butterworth et al., 2013).

The prolonged chasing and capture of dolphins harms not only the individual captured, but can negatively impact the social group and threaten populations and the marine ecosystem (Reeves, Smith, Crespo, & Notarbartolo di Sciara, 2003). The capture of even a few animals may result in the death or injury of many more, since capture involves intensive harassment of dolphin groups. The removal of individuals that model important behavior and transmit specific information within the social group (e.g., caring for young, demonstrating foraging techniques, or locating critical feeding habitats) may have a negative impact on populations. The transmission of information between generations is beginning to be recognised as non-human culture (Lusseau & Newman, 2004; Wells, 2003; Whitehead et al., 2004; Whitehead, 2011; Whitehead & Rendell, 2015; Williams & Lusseau, 2006).

Noren & Edwards (2007) note the significant potential for mother-calf separation, and eventual calf mortality, resulting from chase and encirclement associated with the tuna purse-seine fishery. In these fisheries, dolphins are often chased, encircled and entangled in nets during the course of fishing operations. During fishery evasion, the potential for unobserved calf mortality is quite high if calves are not reunited promptly with their mother. Beyond direct injury and physical separation, even if young calves and neonates are reunited with their mothers during fishing operations, they may also be affected by an influx of stress hormones delivered through the mothers' milk in response to this intermittent but severe experience. The resulting impact on young dolphins could be amplified due to their own immature nervous systems (Noren & Edwards, 2007). Wright et al. (2007) note that "these excessive stress-chemical loads have the potential for generating both acute neurological damage and long-lasting neurological re-programming in any nursing calves in evasion of a tuna purse-seine set in the ETP." (p. 286).

Thus, drive-type hunts and procedures involving chase and encirclement have a great capacity to disrupt social structures and severely impact social groups and populations (Edwards, 2002a; Edwards 2002b; Scillitani, Monaco, & Toso, 2010). Disruption to social structures may have conservation implications in excess of the number of individuals removed. For example, Frère et al. (2010) examined genetic and social effects on female calving success (a partial measure of fitness) in bottlenose dolphins. They determined that both genetic and social factors contribute to variation in individual fitness related to female calving success and suggest that the influence of social relationships between females is consistent with either the social transmission of reproductive prowess, or with a type of homophily in which females with calves associate with other females with calves, thus demonstrating the importance of social relationships to sustainability.

Behavioral and physiological impacts

In reviewing available research on behavioral and physiological impacts of chase and hunt activity on both terrestrial and marine mammals, there is a relative lack of literature on the behavioral and physiological impacts of chase, herding and capture of cetaceans when compared to this area of scientific inquiry in other terrestrial species.

Behavioral responses to stressors can be assessed, but only when individual animals can be observed (Eskesen et al., 2009). During the dolphin drives hunters often actively prevent observation by outsiders. Despite this, the acquisition of investigative video has enabled analysis and documented escape and avoidance behaviors which take place during the chase, herding, separation and collection of individuals during the hunt process (Butterworth et al., 2013).

There are multiple influences on the behavioral responses of the driven animals - including vessel speed, the ‘intensity’ of the sound, the water depth and bathymetry of the ocean, the age, sex and ‘experience’ of the animal, size and composition of the social group—all of which influence stress responses (Kastelein et al., 2000; St. Aubin & Dierauf, 2001; Williams et al., 2017). Social instability, changes in respiratory rate, dive patterns, changed posture, and altered vocalizations are short-term responses to stress in cetaceans (Frohoff, 2004; Waples & Gales, 2002). Behavioral changes resulting from stress or ‘distress’ increase vulnerability and risk of predation, and some species may mask such behaviors to reduce ‘vulnerability’ (Broom, 1991; Esch et al., 2009; Frohoff, 2004; Lusseau, 2003; Pollard et al., 1993; Waples & Gales, 2002).

A stressor can be physical or psychological, and an organism’s response can be acute or chronic. It is understood that mammalian responses have a common neurochemical pathway (Romano et al., 2002; Sapolsky, 1992). When stressed, the hypothalamic-pituitary-adrenal (HPA) axis is stimulated and corticotropin releasing factor (CRF) triggers release of the adreno-corticotropin (ACT) from the pituitary. This in turn induces the secretion of hormones known as adrenocorticoids (glucocorticoids and mineralocorticoids). Although cortisol is the primary glucocorticoid hormone released by this process in most mammals, the presence of corticosterone in adrenocortical tissue has been reported in cetaceans (Carballeira, Brown, Fishman, Trujillo, & Odell, 1987). Glucocorticoids and catecholamines (epinephrine and norepinephrine) cause changes in organ function which include altered rates of gluconeogenesis, and increased heart rate, which contribute to preparedness for ‘fight or flight’ and alterations in the production and release of white blood cells (Guyton & Hall, 2000; Landsberg & Young, 1978; Randall, Burggren, & French, 2002). The effects of cortisol in the animal can be variable, dependent on the context for the animal, including the timing of the stressor, reproductive cyclicity and seasonality (Dobson et al., 2000; Bechshoft et al., 2013), and social and environmental circumstances (Schmitt et al., 2010). The ‘pattern’ of glucocorticoid hormone release may be as important as the amount of hormone released, as the biological effects of the hormones response may take time, and result from hormone receptor interactions which occur across the sometimes-prolonged time duration of the stress response (Laugero, Bell, Bhatnagar, Soriano, & Dallman, 2001; Sheriff, Dantzer, Delehanty, Palme, & Boonstra, 2011).

The effects of glucocorticoids such as cortisol and corticosterone are to generate physiological, behavioral and even anatomical responses to stressors, to affect the endocrinology of the reproductive system, to control energy metabolism, and to impact growth and development in the young animal. Glucocorticoids have been used as indicators of stress responses for a wide range of mammals (Sheriff et al., 2011; Atkinson et al., 2015) and has been collected and analyzed from a variety of tissue and biological materials including blood, urine, faeces and hair (Macbeth et al., 2012) in terrestrial mammals, and from blood, muscle, blubber (Trana et al., 2015; Kellar et al., 2015), faeces (Palme et al., 2013) and from the liquid- cellular component of the blow (Thompson et al., 2014) in cetaceans. Glucocorticoid analyses, sometimes linked to analysis of behavioral change, have been used to increase understanding of the negative impact of human activity in a number of wild animal species, including: hair cortisol analysis for environmental stressors in deer (Caslini et al., 2016); for assessment of environmental change in polar bears (Weisser et al., 2016); ‘landscape fear’ (human persecution) in brown bears (Stoen et al., 2015); capture and handling in brown bears (Cattet et al., 2014); the effects of human harassment in wolves (Bryan et al., 2015); the effects of poaching on elephants (Gobush et al., 2008); tourist pressures on Chamois (Zwijacz-Kozica et al., 2013); and culling and hunting methods in red deer (Cockram et al., 2011) and in other ungulates (Gentsch et al., 2018).

In the absence of direct studies on the behavioral and stress physiology effects of hunting on cetacean species, it is possible to make inferences of the likely impacts of hunting activity from studies which have looked at non-hunting domains of cetacean-human interactions such as whale watching (Avila et al., 2015; Christiansen et al., 2013), or the impacts of anthropogenic sound (Ellison et al., 2012). In the case of hunted cetaceans, it is possible to make ‘informed inferences’ from studies carried out on terrestrial animals where they are hunted or subject to other stressors of human origin.

In cetaceans, physiological impacts from chase and capture may be acute or chronic. Individuals may become entangled in the capture nets and suffocate or suffer fatal stress-related conditions associated with the trauma of capture (Curry, 1999; Schmitt, St. Aubin, Schaefer, & Dunn, 2010; St. Aubin & Geraci, 1988; Thompson & Geraci, 1986). Mortality rates of captured bottlenose dolphins has been shown to increase six-fold immediately after capture and do not decrease to 'normal' levels for up to 45 days suggesting an acute physiological response to the event (Small & DeMaster, 1995).

As well as glucocorticoid hormones circulating in blood and tissues, it is possible that stressors result in measurable changes in more structural cellular elements such as complementary DNA (cDNA). Mancia, Warr, and Chapman (2008) describe a cDNA microarray study, in which analysis of sequence tags (ESTs) which were isolated and sequenced, suggested that the stress response and immune function genes of the bottlenose dolphin could be altered by stressors. The immune system of cetaceans can also be compromised by the stress associated with capture and chase, and can lead to premature death (Romano et al., 2002).

Capture myopathy

During drive hunts, small cetaceans swim in ways that subject them to both acute, and more chronic prolonged stressors for which they are not well adapted. 'Capture myopathy' or 'exertional myopathy' (EM) has been described in a number of species (Bateson & Bradshaw, 1997; Chivers & Myrick, 1991; Curry, 1999; Hartup, Kollias, Jacobsen, Valentine, & Kimber, 1999; Jarrett, Jennings, Murray, & Harthoorn, 1964; Maas, 2000; Maas, 2003; Myrick & Perkins, 1994). Exertional myopathy affects skeletal and cardiac muscle, resulting in muscle necrosis (death of muscle fibers), mitochondrial damage, altered polysaccharide storage in the muscle, and destruction of striated skeletal muscle (Aleman, 2008).

Stress-response blood biochemical profiles observed in offshore spotted and spinner dolphins revealed the presence of acute stress-responses in chased and captured dolphins which include cardiac lesions and other tissue damage (Forney, St. Aubin, & Chivers, 2002). During chase and capture of other hunted species (e.g., deer), disruption of muscle tissue, elevated secretion of endorphins, and high concentrations of cortisol are all typically associated with extreme physiological and psychological stress (Bateson & Bradshaw, 1997). Exertional myopathy stemming from the stress and trauma of chase and capture is associated with a release of high levels of creatine kinase, serum aspartate, and other enzymes resulting from the degradation of cardiac and other muscle tissue which can result in compromised health and even death (Broom & Johnson, 1993; Cattet, Stenhouse, & Bollinge, 2008; Fair & Becker, 2000; Maas, 2003; Myrick & Perkins, 1994; St. Aubin, 2002; St. Aubin et al., 2013).

Exertion associated with hunting red deer (*Cervus elaphus)* resulted in severe physiological disturbances in the animals, and many of the changes appeared seriously maladaptive (Bateson & Bradshaw, 1997). The deer, in many cases, had been pushed beyond limits for which they were physically prepared when subjected to prolonged chases. Lesions consistent with exertional myopathy were documented after postmortems of North American river otters (*Lutra canadensis*) which had been caught and then translocated (Hartup et al., 1999). Results showed that 28% of the otters, which were captured and transported over long distances, and then subjected to a brief period of captivity before release, had abnormal elevations in serum enzymes consistent with myopathy. Exertional myopathy has also been described in captured grizzly bears (*Ursus arctos*) following capture using leg-hold snares in Canada (Cattet et al., 2008). In a number of non-cetacean species, capture myopathy has resulted in death after exertion from complicating factors such as heart failure or partial or complete paralysis (Bartsch, McConnell, Imes, & Schmidt, 1977; Beringer, Hansen, Wilding, Fischer, & Sheriff, 1996; Curry, 1999). In cetaceans, capture myopathy (Spraker, 1993), stress cardiomyopathy (Cebelin & Hirsch, 1980; Colgrove, 1978) and contraction band necrosis, a form of necrosis in cardiac myocytes associated with acute cellular damage (Turnbull & Cowan, 1998), have all been linked to events including capture, transportation, violent assault on cetaceans by humans, and beach stranding in cetaceans.

Many of the scientific findings regarding the physiological impacts associated with chase and encirclement are based on studies conducted as part of a larger research program mandated under the 1997 International Dolphin Conservation Program Act (IDCPA) of the US Marine Mammal Protection Act which have investigated whether the eastern tropical Pacific tuna fishery negatively impacted dolphin stocks. These studies were known collectively as the Chase Encirclement Stress Studies (CHESS) (Forney et al., 2002), and evaluated the degree of acute (i.e., rapid onset, short duration) physiological stress represented by single chase and capture events on cetaceans in the tuna purse seine fishery (Westgate et al., 2007).

The findings of the CHESS and other marine and non-marine mammal studies suggest that chase and encirclement of dolphins results in measurable, and relatively consistent stress responses, in addition to other impacts including physical injury, separation of mothers and calves, and impaired reproductive success (Cramer, Perryman, & Gerrodette, 2008; Edwards, 2006; Matsuda et al., 1996; Noren & Edwards, 2007; St. Aubin et al., 2013). Elevated blood cortisol levels, raised ACTH and catecholamine levels, some elevation of enzymes released from muscle following exertion, and altered white blood cell changes (a shift in the balance of white cell types and an overall net increase in white cell count, the “stress leucogram”) are also reported in the CHESS studies (St. Aubin, 2002).

Conclusion

There is compelling scientific evidence that the process of chase and capture is inhumane. Based on a review of the available scientific data, we contend that the process of drive hunts involving chase, encirclement, and live capture of cetaceans results in physical injury, and physiological and socio-psychological stress which can have enduring negative impacts for individuals and populations. Informed by the CHESS studies, it is our contention that drive hunts, including the chase, subsequent corralling, and handling and selection can have profound negative effects on cetaceans. Based on current knowledge of these animals and the high probability for injury and suffering resulting from pursuit, chase and herding, the authors assert that the drive hunt method cannot be conducted in a humane manner and should be abandoned.

Remarkably, the potential negative impacts of the chase and herding aspects of the drive hunts are absent from policy discussions relating to the methods used to collect dolphins from the wild for marine parks or aquaria. There is a striking disparity between the information we have reviewed in this paper and policymaking decisions regarding the hunting and collection of small cetaceans in general. Noting that advancements in animal welfare policy in modern zoological institutions are science-based, we encourage zoological institutions to acknowledge the adverse impacts of chase and capture on individuals and populations of delphinid species during acquisition from the wild. We argue that based upon the evidence provided herein, the live collection of any cetaceans from the wild should be discontinued, or at least reconsidered.

Supplementary videos (S1 and S2)

Contact first or corresponding author for videos at: courtney@lightkeepersfoundation.com, or Diana Reiss, dlr28@columbia.edu

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Figure Captions

Figure 1. A fleet of boats returns from a dolphin drive hunt in Taiji, Japan. Image: DolphinProject.com

Figure 2. a) Metal trumpets utilized in the dolphin drive hunts. b) Trumpets (indicated by circle) are mounted on vessels and placed in the water. Using a hammer or other object, fishermen bang on the poles to create loud noise (up to 205dB) that disorients the dolphins. Image: Courtney Vail

Figure 3. a) A group of Risso's dolphins is corralled behind nets at the conclusion of a drive hunt. Image: DolphinProject.com/Marna Frida Olsen. b) After chase and confinement in a cove, live Risso's dolphins are tethered and towed. Image: DolphinProject.com/Marna Frida Olsen. c) While still alive, struggling dolphins are tethered by their tails for towing to the slaughter area (indicated by smaller circle). Other free-swimming dolphins (indicated by larger circle) in close proximity to those tethered. Image: AtlanticBlue.de

Figure 4. a) A dolphin is secured in a net after selection for a marine park. Image: Sea Shepherd Conservation Society. b) An obviously injured bottlenose dolphin being restrained during selection for a marine park after a drive hunt. Image: Sea Shepherd Conservation Society

Supplemental Video Material

Supplementary Video 1

https://www.dropbox.com/s/m33kw01r4uy5ft9/S1%20Video%20Tail%20tether.mp4?dl=0

Supplementary Video 2

https://www.dropbox.com/s/siime5c85f13fuu/S2%20Video%20Blood%20in%20Taiji%20Cove%2C%20January%2018%2C%202011.mp4?dl=0